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SCOOP TRIDENT REPAIR PART SUPPORT PACKAGE

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OPERATIONS ANALYSIS DEPARTMENT

NAVY FLEET MATERIAL SUPPORT OFFICE

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SCOOP TRIDENT REPAIR

PART SUPPORT PACKAGE

PROJECT NUMBER

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REPORT 171

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ABSTRACT

Adverse conditions at the TRIDENT Refit Facilities (TRFs) may force submarines to obtain their replenishment at a non-Navy port. Replenishment requirements (Pull Package) are required, without knowledge of what was used in the current patrol, to provide the submarine with sufficient replenishment support to complete another patrol. The first part of this study evaluates alternative methods for computing Pull Packages. These methods include generic versus hull-tailored, demand-based versus the Best Replacement Factor (BRF) based, excluding items with sufficient On-Board Replacement Assets (OBRA), and using Military Essentiality Codes (MECs). The alternatives are evaluated in terms of effectiveness, size of package and cost. The second part of this study examines frequency of update and Pull Package refinements. We recommend deleting the OBRA items from consideration and annually computing a generic, demand-based Pull Package with range based on MEC and depth based on average demand quantity for those patrols experiencing demand.

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EXECUTIVE SUMMARY

1. **Problem and Background**. Adverse conditions may force the TRIDENT Refit Facilities (TRFs) to be unavailable for submarine replenishment support, and therefore the submarines may need to obtain their replenishment at a non-Navy port. In this situation, the repair part replenishment requirements (Pull Package) need to be determined without prior knowledge of the submarine's requirements. This Pull Package must provide the submarine with enough replenishment support to allow the submarine to complete another 70 day patrol.

2. **Objective**. To determine the "optimum" Pull Package to be delivered to a submarine, in a non-Navy port, without prior knowledge of the submarine's requirements.

3. **Approach**. The TRF demand history file covering the period from October 1986 to January 1989 for eight TRIDENT submarines was used in this study. We extracted replenishment and corrective maintenance requisition data while deleting office supplies, equipage, medical and dental requisitions. For each submarine, we gathered statistics for the demands experienced during its patrol plus the number of demands experienced during the refit, but before the next patrol. Various options for building a basic Pull Package were evaluated. They are listed below in the order of evaluation.

- Tailoring Pull Packages to each hull versus a generic Pull Package to be used for all Unit Identification Codes (UICs).

- Using only observed demand data to create a Pull Package versus supplementing demand with Best Replacement Factors (BRFs).

- Removing items from the Pull Package candidates list which had sufficient On-Board Replacement Assets (OBRA) to satisfy the demand from two normal patrols.

- Using Military Essentiality Codes (MECs) to allow more support for higher essential items than less essential items.

To evaluate the alternatives, we first set aside replenishment demands from the last complete patrol (including refit) for use as an evaluation patrol. Then a Pull Package was built based on the demand history from the four previous patrols. The Pull Package was then evaluated based on:

- Size (number of National Item Identification Numbers (NIINs)) of the package.

- Cost (from the end-user's perspective) of the package.

- Process NIIN effectiveness (what percentage of the items requested during the submarine's evaluation patrol are satisfied).

- Pull Package effectiveness (what percentage of the items in the package are actually needed by the submarine in the evaluation patrol).

After developing a basic Pull Package, we then addressed how frequently the Pull Package should be updated and examined ways of improving the performance of the Pull Package.

4. Findings. Based on the statistics presented in this report, we concluded that the best way to create a Pull Package was to use a generic, demand-based approach with separate range cutoffs for the different MECs and deleting items with sufficient OBRA. The range cutoffs we used satisfied 89-90% of the most critical NIINs demanded during the patrol, 73% of all the NIINs demanded, and kept the package size within practical limits. Depth should be based on the

average demand quantity for the patrols that experienced demand. Finally the Pull Package should be computed once a year. As part of this study, we developed Pull Packages for both FY89 and FY90. The FY90 Pull Package has 2,777 NIINs and costs $761K. Process NIIN and Pull Package effectiveness are projected to be 73% and 13%, respectively, similar to the FY89 Pull Package. The SCOOP Logistics Planning team conducted an actual SCOOP test of the FY89 Pull Package. The Pull Package performed better than expected, resulting in a Process NIIN effectiveness of 78% for the USS GEORGIA and 83% for the USS ALABAMA.

I. INTRODUCTION

The Navy SSBN Continuity of Operations (SCOOP) program is designed for the replenishment, repair, and crew changes of TRIDENT submarines during wartime conditions. Under normal conditions, submarines return to the TRIDENT Refit Facility (TRF) for replenishment, but during wartime this may not be feasible. Access to the TRF might be cut off or not convenient depending on the location of the submarine. The submarines may need to obtain their spare repair parts at a remote port, a non-Navy port, or while underway on the ocean. Due to tactical considerations the submarine may choose not to communicate her re-quirements during her current patrol; therefore, a method is needed to deter-mine the repair part requirements without prior knowledge. These repair parts are then pushed to a pre-determined site and the submarine then pulls her requirements from the positioned material. Reference 1 of APPENDIX A ini-tiated a study to develop a method to determine which spare parts to provide the submarine (Pull Package) in order to allow the submarine to continue operations for a second patrol without returning to the TRF. The Pull Package should maximize the replenishment rate for National Item Identification Num-bers (NIINs) demanded during the current patrol while keeping the package size within practical limits.

II. BASIC PULL PACKAGE APPROACH

The Pull Package alternatives, data sources and methods of evaluation are described in the following paragraphs.

A. ALTERNATIVES. We evaluated various options for building a Pull Package. First, we looked at building hull-tailored Pull Packages versus building one generic Pull Package to be used for all Unit Identification Codes (UICs). Second, we looked at a strictly demand-based Pull Package versus

considering items with high demand potential based on the item's Best Re-placement Factor (BRF). Third, we removed items as Pull Package candidates when they had sufficient On-Board Replacement Assets (OBRA) allowed by the Coordinated Shipboard Allowance List (COSAL) to satisfy the demand from two normal patrols. Finally, we used Military Essentiality Codes (MECs) to describe essentiality and then included more of the higher MEC items in the package.

B. DATA. We used the TRF Bangor demand history file covering the period from October 1986 to January 1989 for seven UICs (21036, 21037, 21038, 21039, 21040, 21041, and 21042). TABLE I cross references UIC with hull number and name. We extracted requisitions with project codes of either "XE_" (replen-ishment) or "XK_" (corrective maintenance), then deleted those requisitions having fund code equal to "ZC" (office supplies), "ZE" (equipage), or "Z7" (medical/dental). TABLE II shows the number of demands experienced during each patrol as well as the number of demands experienced during the refit but before the next patrol.

TABLE I

Test Ships

UIC	SSBN	SHIP NAME
21036	726	OHIO
21037	727	MICHIGAN
21038	728	FLORIDA
21039	729	GEORGIA
21040	730	HENRY M. JACKSON
21041	731	ALABAMA
21042	732	ALASKA
21043	733	NEVADA

TABLE II

Demand Frequency by Patrol

UIC	PATROLS								
	P1	P2	P3	P4	P5	P6	P7	P8	P9
21036	696	628	609	531	645	451	424	430	470
	472	602	460	378	355	421	496	400	127
21037	650	808	570	418	399	512	293	492	
	448	739	531	495	473	483	282	431	
21038	626	460	452	388	566	523	530	561	
	496	723	751	703	430	465	531	342	
21039	313	662	435	393	518	307	409	582	623
	503	411	681	593	523	577	535	563	284
21040	425	604	624	282	342	605	362	123	
	532	425	592	445	496	376	635	323	
21041	508	256	401	468	533	493	349	320	588
	531	390	366	370	421	677	591	390	392
21042	767	667	391	419	704	421	472	467	
	473	661	426	421	309	341	493		

NOTE: Top # - Demand during patrol dropped the first day back.
       Bottom # - Demand during refit but before next patrol.

We obtained the COSAL allowance file from VITRO, which contains computed allowances as of January 1989. This file was used to identify OBRAs. For NIINs that had different COSAL quantities on different submarines, we used the smallest quantity. The Navy Ships Parts Control Center (SPCC) provided us with MEC data as of January 1989. Finally, we used the BRFs contained in the SPCC BRF file as of January 1989.

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C. **METHODS OF EVALUATION**. While we built the Pull Package using both corrective maintenance and replenishment demands, we only used the actual replenishment demands for evaluating the Pull Package. In order to evaluate the alternatives, we extracted replenishment demands from the last complete patrol (including refit) for use as an evaluation patrol. We then built our alternative Pull Packages using the four previous patrols as the demand history or "candidates". Finally, we evaluated our alternative Pull Packages based on their size, cost and effectiveness. By size of the package, we simply mean the number of different NIINs in the package. During reference (2) of Appendix A, we were asked to price the package from the perspective of the end-user. Thus, Appropriation Purchase Account (APA) items (even Cogs) were considered free (unit price equals zero). Also, Depot Level Repairable (DLR) items (7 Cog) were priced at their net price (which assumes a carcass is turned in). For all 1 and 9 Cog items, we used the standard (or unit) price. We look at the effectiveness from three different perspectives: NIIN effectiveness, Process NIIN effectiveness and Pull Package effectiveness. NIIN effectiveness tells us what percent of the NIINs requested during the evaluation patrol are satisfied by the Pull Package. Process NIIN effectiveness considers the contribution of the OBRA items and shows the percent of the NIINs requested during evaluation patrol that can be satisfied by either the Pull Package or OBRA. Both NIIN and Process NIIN effectiveness are from the perspective of the submariner and tell you how happy he is with the Pull Package. Meanwhile, the Pull Package effectiveness measures how "good" the package is from the perspective of the person who is putting the package together who wants to know how many NIINs in the package the submarine actually needs (i.e., what the "turnover" rate is). The following equations explain the computation of the different types of effectiveness.

$$\text{NIIN EFFECTIVENESS} = \frac{\text{\# OF NIINs DEMANDED THAT ARE IN PULL PACKAGE}}{\text{TOTAL \# NIINS DEMANDED IN EVALUATION PERIOD}}$$

$$\text{PROCESS NIIN EFFECTIVENESS} = \frac{\text{\# OF NIINs DEMANDED THAT ARE IN PKG OR ARE OBRA}}{\text{TOTAL \# NIINS DEMANDED IN EVALUATION PERIOD}}$$

$$\text{PULL PACKAGE EFFECTIVENESS} = \frac{\text{\# OF NIINs DEMANDED THAT ARE IN PULL PACKAGE}}{\text{\# PULL PACKAGE NIINs}}$$

III. BASIC PULL PACKAGE FINDINGS

A. <u>HULL-TAILORED VS. GENERIC</u>. To determine whether to use a generic or a hull-tailored approach, we looked at first time demand patterns. First time demand is demand occurring in the evaluation patrol which did not occur previously. First time demand is impossible to predict from history, since we have no history. We looked at first time demand using a hull-tailored approach (looking at one UIC by itself) and using a generic approach (looking at all UICs together). TABLE III shows the percentage of demand that occurred the first time for each UIC when using a hull-tailored approach. That is, demand that occurred in the evaluation patrol of a given UIC, that had not occurred in that particular UIC's previous six patrols demand history. Using a hull-tailored approach, an average of 25% of evaluation period demands were first time demands. Thus, if we build a hull-tailored Pull Package for UIC 21036 and included all items with at least one demand in the past six patrols we would only achieve a NIIN effectiveness of 74%, since 26% of the demands in the evaluation period were first time demands.

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TABLE III

First Time Demands by UIC Using a Hull-Tailored Approach

UIC	21036	21037	21038	21039	21040	21041	21042	AVG
% FIRST TIME DEMAND	26	32	29	16	25	22	24	25

Using a generic approach allows us to look at the demand history from all submarines, not just the submarine for which we are building the Pull Package. If the demands for different UICs are similar, looking at historical demand from all UICs instead of just one UIC should lower the percentage of first time demand for each individual UIC. This is because a particular UIC's first time demand will not be first time demand across all UICs if the demand already occurred on a different UIC. TABLE IV shows the percentage of first time demand for each UIC when using a generic approach. That is, demand that occurred in the evaluation patrol of a given UIC which had not occurred in any UIC's previous patrols. Using a generic Pull Package for UIC 21036 and including all items with any demands over the past six patrols yields a NIIN effectiveness of 84%, a 10 percentage point gain over the hull-tailored package.

TABLE IV

First Time Demands by UIC Using a Generic Approach

UIC	21036	21037	21038	21039	21040	21041	21042	AVG
% FIRST TIME DEMAND	16	18	19	16	18	18	16	17

We found that when using a generic approach, an average of 17% of demands were first time demands versus the 25% average when using the hull-tailored approach. The lower percentage of first time demand, in addition to the similar results across all UICs, shows us that the different submarines have

similar demands. We, therefore, concluded that the best way to build a Pull Package is to develop one generic Pull Package for use on any submarine based on historical data from all submarines.

B. DEMAND-BASED VS BRF. We built a generic, demand-based Pull Package and then looked at supplementing it with high BRF items. To build a generic, demand-based Pull Package, we looked at each NIIN demanded in terms of (1) how many UICs demanded that NIIN and (2) on how many patrols was it demanded. Since we used four patrols of history and seven UICs, a NIIN could have been demanded on up to 28 patrols. TABLE V shows the distribution of NIINs demanded during the history period. The numbers across the top, the "x" values, represent the number of UICs demanding a particular NIIN. The numbers down the side, the "y" values, represent the number of patrols on which a particular NIIN was demanded. The entries or "cells" in the table represent the number of NIINs that were demanded on "y" patrols for "x" UICs. For example, cell 3,2 contains the number 232. This means that 232 NIINs were demanded on exactly three patrols by exactly two UICs. So, for a given NIIN in that cell, one UIC demanded that NIIN twice and a second UIC demanded that same NIIN once. TABLE V also shows that there were a total of 7,688 unique NIINs demanded across all UICs during the four patrol history period.

TABLE VI displays the data from TABLE V in a cumulative fashion. In TABLE VI, a cell represents the number of NIINs demanded in "y" or more patrols by "x" or more UICs. For example, the number 2,033 in cell 3,2 means that 2,033 NIINs were used on three or more patrols by two or more UICs. Cell 1,1 contains the total number of unique NIINs demanded across all UICs during the four patrol history period (7,688). To build a generic, demand-based Pull Package, you would select a package size and use the cell values associated with that number of NIINs for the range cutoff. For example, if you wanted a

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package size of 1,000, you would see that cell 5,4 contains 1,009 NIINs, and therefore, the range cutoff values would be five or more patrols and four or more UICs.

TABLE V

Distribution of NIINs Demanded

UICs

# PATROLS	1	2	3	4	5	6	7	TOTALS
1	4352	-	-	-	-	-	-	4352
2	282	995	-	-	-	-	-	1277
3	22	232	330	-	-	-	-	584
4	4	45	167	121	-	-	-	337
5	-	9	77	116	34	-	-	236
6	-	1	27	65	42	9	-	144
7	-	1	11	40	42	22	1	117
8	-	0	1	28	41	25	5	100
9	-	-	1	14	30	24	12	81
10	-	-	1	3	22	25	6	57
11	-	-	0	0	16	31	17	64
12	-	-	0	0	7	25	10	42
13	-	-	-	0	6	17	15	38
14	-	-	-	0	6	17	15	38
15	-	-	-	0	2	12	24	38
16	-	-	-	0	0	9	16	25
17	-	-	-	-	0	5	21	26
18	-	-	-	-	0	4	18	22
19	-	-	-	-	0	3	25	28
20	-	-	-	-	0	3	11	14
21	-	-	-	-	-	1	16	17
22	-	-	-	-	-	0	9	9
23	-	-	-	-	-	0	10	10
24	-	-	-	-	-	0	7	7
25	-	-	-	-	-	-	10	10
26	-	-	-	-	-	-	7	7
27	-	-	-	-	-	-	6	6
28	-	-	-	-	-	-	2	2
TOTALS	4660	1283	615	387	248	232	263	7688

TABLE VI

Cumulative Distribution of NIINs Demanded

UICs

# PATROLS	1	2	3	4	5	6	7
1	7688	-	-	-	-	-	-
2	3336	3028	-	-	-	-	-
3	2059	2033	1745	-	-	-	-
4	1475	1471	1415	1130	-	-	-
5	-	1138	1127	1009	743	-	-
6	-	902	900	859	709	495	-
7	-	758	757	743	658	486	263
8	-	641	641	638	593	463	262
9	-	-	541	539	522	433	257
10	-	-	460	459	456	397	245
11	-	-	403	403	403	366	239
12	-	-	339	339	339	318	222
13	-	-	-	297	297	283	212
14	-	-	-	259	259	251	197
15	-	-	-	221	221	219	182
16	-	-	-	183	183	183	158
17	-	-	-	-	158	158	142
18	-	-	-	-	132	132	121
19	-	-	-	-	110	110	103
20	-	-	-	-	82	82	78
21	-	-	-	-	-	68	67
22	-	-	-	-	-	51	51
23	-	-	-	-	-	42	42
24	-	-	-	-	-	32	32
25	-	-	-	-	-	-	25
26	-	-	-	-	-	-	15
27	-	-	-	-	-	-	8
28	-	-	-	-	-	-	2

TABLE VII shows the cumulative NIIN effectiveness values for UIC 21036 associated with the NIINs in the corresponding cells of TABLE VI. For example, the package in cell 5,4 which had 1,009 NIINs yields 48% NIIN effectiveness for UIC 21036. We also developed cumulative tables for cost and Pull Package effectiveness. Since these tables are similar in structure to TABLEs VI and VII, we have not included them in the report. However, selected values from these tables are included in summary tables shown later.

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TABLE VII

Cumulative Distribution of UIC 21036 NIIN Effectiveness for a Generic Package

UICs

# PATROLS	1	2	3	4	5	6	7
1	84	-	-	-	-	-	-
2	72	70	-	-	-	-	-
3	65	64	60	-	-	-	-
4	57	56	56	50	-	-	-
5	-	51	51	48	41	-	-
6	-	47	47	46	41	33	-
7	-	44	44	43	39	33	21
8	-	39	39	39	37	32	21
9	-	-	35	35	34	30	21
10	-	-	32	32	32	29	20
11	-	-	29	29	29	27	20
12	-	-	26	26	26	25	19
13	-	-	-	24	24	23	19
14	-	-	-	22	22	21	18
15	-	-	-	19	19	19	16
16	-	-	-	17	17	17	14
17	-	-	-	-	15	15	14
18	-	-	-	-	13	13	12
19	-	-	-	-	12	12	11
20	-	-	-	-	9	9	9
21	-	-	-	-	-	8	8
22	-	-	-	-	-	7	7
23	-	-	-	-	-	6	6
24	-	-	-	-	-	4	4
25	-	-	-	-	-	-	4
26	-	-	-	-	-	-	2
27	-	-	-	-	-	-	1
28	-	-	-	-	-	-	0

To evaluate a Pull Package, we matched the evaluation patrol demand for each UIC against the items in that Pull Package (NIINs passing the range cutoffs). This means we developed a table similar to TABLE VII for each UIC. TABLE VIII shows the NIIN effectiveness (percentage of evaluation NIIN demands filled by the package) and Pull Package effectiveness (percentage of NIINs in the package actually demanded during the evaluation period) values for each UIC for three Pull Package sizes and the average values across all UICs. TABLE VIII shows that if we could put every item demanded in the Pull Package

(7,688 items corresponding with cell 1,1 of TABLE VI), we would reach an average of 83% NIIN effectiveness and 7% Pull Package effectiveness. The NIIN effectiveness is limited to 83% because 17% of the demands are first time demands (as previously shown in TABLE IV), so they would not have shown up in our data base used to create the Pull Package. The Pull Package effectiveness is low because the package is so large and we only need a small percentage of the items. When we limit the size of the Pull Package to 541, TABLE VIII show that we would get a much higher Pull Package effectiveness (45%), but a lower NIIN effectiveness (36%). The Pull Package of 1,009 falls between the other two.

TABLE VIII

Summary of Effectiveness by UIC

NIIN Effectiveness/Pull Package Effectiveness

	ALTERNATIVE PACKAGES					
	7688 ITEMS @ $1.47M		541 ITEMS @ $93K		1009 ITEMS @ $163K	
UIC	NIIN	PULL PKG	NIIN	PULL PKG	NIIN	PULL PKG
21036	84	7	35	43	48	31
21037	82	5	36	31	47	22
21038	81	8	35	50	48	36
21039	84	9	32	51	46	40
21040	82	8	37	50	50	36
21041	82	6	37	39	48	27
21042	84	8	40	52	54	38
AVG	83	7	36	45	49	33

When using demand history to build the Pull Package, certain items with no previous demand limit the effectiveness we can reach. We looked at using BRFs

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as an indicator of items which have a high probability of experiencing demand and therefore belong in the Pull Package. We took the COSAL file and found the BRF cut-off values that would give us various Pull Package sizes. For example, 575 NIINs had BRFs of .99 or greater. So, to build a package of approximately 550 NIINs, we would include all COSAL items having a BRF of .99 and greater. We then evaluated the various Pull Packages by determining the effectiveness values and comparing them with the values we would get using the demand-based method. TABLE IX shows the NIIN effectiveness comparison between the BRF and demand-based methods for various size Pull Packages. For the same size package, the demand-based package performed significantly better than the BRF based package. As we decreased the BRF cutoff value, the size of the package increased dramatically. We found that even if we used a BRF cutoff value of 0, that is, create a Pull Package using the entire COSAL file (17,632 NIINs), the maximum NIIN effectiveness we could obtain was 75%. We concluded that it is better to build a Pull Package based solely on demand than one based solely on the BRF.

TABLE IX

NIIN Effectiveness

APPROX. PACKAGE SIZE	PULL PACKAGE STRICTLY BASED ON	
	BRF	DEMAND
550	7%	35%
860	12%	46%
1150	16%	50%
1500	20%	57%
3350	36%	72%
7700	55%	84%

We also looked at using BRFs to supplement our demand-based Pull Package in an effort to limit the Pull Package size while picking up those items which had not yet experienced demand but would be likely to in the future. We attempted to reach 90% NIIN effectiveness. When we supplemented the Pull Package of 7,688 items (which yielded 84% NIIN effectiveness for UIC 21036) with high BRF items, we found that we needed a package of 12,000 NIINs to reach 90% NIIN effectiveness for that UIC. We concluded that, although we can achieve 90% NIIN effectiveness by combining the demand-based method with the BRF method, the size of this Pull Package is not practical. It is better to base the Pull Package on demand alone.

C. DEMAND-BASED MINUS OBRA. To help keep the Pull Package size within practical limits, we removed from consideration as Pull Package candidates those items with "sufficient" OBRA. We defined "sufficient" to mean that (1) the COSAL quantity equals three or more and (2) the COSAL quantity exceeds twice the average patrol demand. We did not remove from consideration any Strategic Weapons System (SWS) or Nuclear Reactor Plant (NRP) items. We found that 1,459 of the 7,688 candidates have allowances which appeared to be sufficient to satisfy the demand for two normal patrols. TABLE X shows the cumulative distribution of NIINs demanded after deleting the OBRA items. TABLE XI shows the cumulative distribution of Process NIIN effectiveness for UIC 21036, when the OBRA items are not in the package, but since we are now looking at Process NIIN effectiveness their contribution is included in the effectiveness numbers. TABLE XII shows the Process NIIN effectiveness and Pull Package effectiveness for the three different package sizes shown in TABLE VIII.

TABLE X

Cumulative Distribution of NIINs Demanded Not Including OBRA Items

UICs

# PATROLS	1	2	3	4	5	6	7
1	6229	-	-	-	-	-	-
2	2414	2170	-	-	-	-	-
3	1399	1381	1168	-	-	-	-
4	960	957	920	723	-	-	-
5	-	728	719	639	473	-	-
6	-	565	564	539	453	328	-
7	-	473	473	463	420	323	191
8	-	406	406	405	384	309	190
9	-	-	348	348	339	293	187
10	-	-	298	298	297	271	179
11	-	-	267	267	267	251	176
12	-	-	233	233	233	223	166
13	-	-	-	206	206	199	158
14	-	-	-	189	189	184	151
15	-	-	-	161	161	159	139
16	-	-	-	138	138	138	123
17	-	-	-	-	124	124	113
18	-	-	-	-	104	104	97
19	-	-	-	-	91	91	86
20	-	-	-	-	71	71	68
21	-	-	-	-	-	61	60
22	-	-	-	-	-	49	49
23	-	-	-	-	-	40	40
24	-	-	-	-	-	31	31
25	-	-	-	-	-	-	24
26	-	-	-	-	-	-	14
27	-	-	-	-	-	-	8
28	-	-	-	-	-	-	2

TABLE XI

Cumulative Distribution of UIC 21036 Process NIIN Effectiveness

for a Generic Package

UICs

# PATROLS	1	2	3	4	5	6	7
1	84	-	-	-	-	-	-
2	75	74	-	-	-	-	-
3	70	70	67	-	-	-	-
4	65	65	64	62	-	-	-
5	-	63	63	61	57	-	-
6	-	61	61	60	57	54	-
7	-	58	58	58	56	53	47
8	-	56	56	56	55	53	47
9	-	-	54	54	53	52	47
10	-	-	52	52	52	51	47
11	-	-	51	51	51	50	47
12	-	-	49	49	49	49	46
13	-	-	-	48	48	48	46
14	-	-	-	48	48	47	46
15	-	-	-	46	46	46	45
16	-	-	-	45	45	45	43
17	-	-	-	-	44	44	43
18	-	-	-	-	43	43	42
19	-	-	-	-	42	42	42
20	-	-	-	-	40	40	40
21	-	-	-	-	-	39	39
22	-	-	-	-	-	39	39
23	-	-	-	-	-	37	37
24	-	-	-	-	-	36	36
25	-	-	-	-	-	-	35
26	-	-	-	-	-	-	34
27	-	-	-	-	-	-	33
28	-	-	-	-	-	-	32

Comparing TABLE XII to TABLE VIII, we see that for similarly sized and priced packages (e.g., 540 NIINs at $94K) the Process NIIN effectiveness improves by 22 percentage points (from 36% to 58%). We concluded that deleting OBRA items as candidates improves the Process NIIN effectiveness of the package and allows us to keep the size of the package within more manageable limits.

TABLE XII

Summary of Effectiveness

by UIC

Process NIIN Effectiveness/Pull Package Effectiveness

	ALTERNATIVE PACKAGES					
	6229 ITEMS @ $1.3M		539 ITEMS @ $94K		920 ITEMS @ $174K	
UIC	PROCESS NIIN	PULL PKG	PROCESS NIIN	PULL PKG	PROCESS NIIN	PULL PKG
21036	84	5	60	34	64	23
21037	82	4	53	25	61	19
21038	81	6	57	39	63	28
21039	84	7	57	42	62	29
21040	82	6	57	41	63	29
21041	82	5	58	31	63	21
21042	83	6	61	43	66	29
AVG	83	6	58	36	63	25

D. **USE OF MECs**. To tailor the package to more critical items, we considered the MEC in addition to the demand history. TABLE XIII defines the MECs and provides a distribution of the candidates by MEC.

TABLE XIII

MEC Definitions and Distribution

MEC	DEFINITION	NON-OBRA ITEMS W/DMD
95	Negligible Degradation	3962
98		351
101	Partial Degradation	407
104		24
107		84
110	Totally Degrade Missile Launch Capability	532
116*	Mission Abortion	869
		6,229

*MEC - 116 Assumed for NRP Items

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TABLE XIV shows the distribution by MEC of the number of NIINs and the cost for five different size Pull Packages. TABLE XV shows the corresponding Process NIIN and Pull Package effectiveness. These tables allow us to mix and match the range cutoffs between MEC groupings in ways that will maximize NIIN effectiveness while keeping the Pull Package size within practical limits. During reference (c), the SCOOP Logistics Planning team decided to maximize NIIN effectiveness for MEC 116 and 110 items by using the range cutoff of cell 1,1. In other words, MEC 116 and 110 items having demand on at least one patrol from at least one UIC will be added to the Pull Package. MEC 98 through MEC 107 items having demand on at least two patrols (cell 2,1) will be added to the Pull Package. Finally, MEC 95 items having demand on at least three patrols from at least two UICs (cell 3,2) will be added to the Pull Package. (The selected values are highlighted in TABLEs XIV and XV.) TABLE XVI shows the incremental and total size, cost, Process NIIN effectiveness, and Pull Package effectiveness for the Pull Package using these range cutoffs.

TABLE XIV

Distribution of # NIINs/Cost by MEC

	ALTERNATIVE PULL PACKAGES AS DEFINED BY # PATROLS - # UICs NEEDED TO BE PART OF PKG									
	6-4		4-3		3-2		2-1		1-1	
MEC	NIINs	COST	NIINs	COST	NIINs	COST	NIINs	COST	NIINs	COST
95	309	44	547	68	838	126	1,472	221	3,962	642
98-107	68	24	113	35	167	50	314	85	866	245
110	41	8	93	47	143	68	242	121	532	215
116	121	19	167	25	233	51	386	84	869	245
TOTAL*	539	$94K	920	$174K	1,381	$293K	2,414	$511K	6,229	$1.35M

* NOTE: Cost totals may not add due to rounding.

TABLE XV

Distribution of Process NIIN/Pull Package Effectiveness

by MEC

	ALTERNATIVE PULL PACKAGES AS DEFINED BY # PATROLS - # UICs NEEDED TO BE PART OF PKG									
	6-4		4-3		3-2		2-1		1-1	
MEC	NIINs	PULL PKG	NIINs	PULL PKG	NIINs	PULL PKG	NIINs	PULL PKG	NIINs	PULL PKG
95	52	36	59	25	65	19	72	12	81	5
98-107	57	35	62	26	64	19	70	12	81	6
110	67	31	74	21	77	16	81	11	89	7
116	65	40	69	32	73	25	78	16	84	8
TOTAL	58	36	63	25	68	19	74	13	83	6

TABLE XVI

FY89 Pull Package

	# NIINs	COST	PROCESS NIIN EFFECTIVENESS	PULL PACKAGE EFFECTIVENESS
MEC 116 ITEMS WITH DEMAND ON AT LEAST ONE PATROL	869	$245K	84	8
MEC 110 ITEMS WITH DEMAND ON AT LEAST ONE PATROL	532	$215K	89	7
MEC 98-107 ITEMS WITH DEMAND ON AT LEAST TWO PATROLS	314	$ 85K	70	12
MEC 95 ITEMS WITH DEMAND ON AT LEAST THREE PATROLS FROM TWO DIFFERENT SSBNs	838	$126K	65	19
TOTAL	2553	$671K	73	12

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We concluded that the best method for building a Pull Package is to use a generic, demand-based approach with separate range cutoffs for the different MECs. The range cutoffs we used satisfied 84-89% of the most critical NIINs demanded during the patrol, 73% of all the NIINs demanded, and kept the package size within practical limits.

IV. PULL PACKAGE REFINEMENTS

In the first part of this study, we evaluated different alternatives for developing a basic Pull Package. TABLE XVI showed the results of combining the best of these alternatives to compute the FY89 Pull Package. An actual SCOOP test was conducted using the FY89 Pull Package with the USS GEORGIA and USS ALABAMA as the test submarines. This actual test resulted in a Process NIIN effectiveness of 78% and 83% for the USS GEORGIA and USS ALABAMA, respectively. These test results exceeded our forecasted Process NIIN effectiveness (73%) and validated our approach to developing basic Pull Packages. Our next step was to examine how often we should update our Pull Package in order to reflect current demand patterns and to remove items no longer demanded Once we determined frequency of updating, we then examined additional ways to improve the performance of the high essentiality (MEC 110/ 116) items, depth computations and OBRA computations. The following paragraphs describe our approach and findings for each of these topics.

A. FREQUENCY OF UPDATING.

1. APPROACH. We investigated three alternative procedures for determining when to update the Pull Package. A Pull Package could be computed after each submarine completes her patrol, quarterly (using data from the submarines which completed their patrol since the previous quarter's update)

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or once a year (using data from all patrols completed since the last update). There are drawbacks in using any one of these possibilities. Computing a Pull Package after each individual submarine patrol can be costly in terms of Navy Stock Fund (NSF) dollars and manpower. Given that we have eight submarines, a Pull Package would be computed every two or three weeks. Churn would become a major issue. Items may be deleted after one patrol and then added again after the next patrol. Consequently, we limited our data analysis to quarterly and annual updates. Any recalculation of a Pull Package lends itself to a timing problem. Patrols (including refit) normally last 90 to 100 days. With that in mind, a given number of submarines will be on patrol whenever the package is recomputed. At the start of a patrol, a submarine receives a list of Pull Package items in case she has a demand for a critical item not on the list. If this happens, she could submit a message requesting that the critical item be included on their Pull Package. If the package changes while the submarine is underway, confusion may result. The submarine may need an item on the "old" package and think that she will receive that item as part of the Pull Package. However, if by chance that particular item is no longer on the "new" Pull Package, then the submariner will not get that item unless the people sending the Pull Package out keep two Pull Packages on hand so they can send the old one to those submarines which are still operating under the old list and the new package to those who have switched over to the new list. In order to answer the question how often to update, we will consider the trade-off between stability and responsiveness to new trends by comparing quarterly to annual updates.

To determine how often to update, we used the same range rules used to construct the FY89 Pull Package. Using the annual update concept, we built a Pull Package using patrols one through four (our four oldest patrols). Then

we determined Process NIIN/Pull Package effectiveness for each of the next three patrols (patrols five, six and seven). Using the quarterly update concept, we recomputed the Pull Package based on patrols two through five and used the sixth patrol to determine Process NIIN/Pull Package effectiveness. We then recomputed the package again using patrols three to six to develop the Pull Package and the seventh patrol to determine Process NIIN/Pull Package effectiveness. We developed statistics comparing effectiveness based on an annual Pull Package evaluated over three patrols and a Pull Package updated quarterly.

2. FINDINGS. TABLE XVII displays the average Process NIIN/Pull Package effectiveness across all UICs by MEC category. The first part of the table was developed by computing an annual Pull Package, using patrols one through four and evaluated this constant Pull Package against the demands that occurred in patrols five, six and seven. Focusing our attention on the ALL category, we can see that there is only a one to two percentage point difference in the overall effectiveness between the patrols. Next we compared the recomputed quarterly Pull Packages to the demands in the subsequent patrol. Comparing the annual Pull Package to the quarterly updated Pull Package for the same evaluation patrol (the columns labeled patrol 6 and patrol 7), we observe that the quarterly update of the Pull Package provided a maximum of two percentage points increase in effectiveness over the constant Pull Package for the same evaluation patrol.

TABLE XVII

Average - Process NIIN/Pull Package Effectiveness

	DEVELOPED FROM PATROLS									
	1-4						2-5		3-6	
	PATROL 5		PATROL 6		PATROL 7		PATROL 6		PATROL 7	
MEC	NIIN	PULL PKG	NIIN	PULL PKG	NIIN	PULL PKG	NIIN	PULL PKG	NIIN	PULL PKG
95	63	20	63	18	64	16	65	19	65	17
98-107	69	13	69	11	67	10	70	11	71	11
110	85	7	91	6	86	5	92	6	89	9
116	86	10	88	10	85	8	88	9	85	8
ALL	71	13	72	12	71	11	74	12	73	11

Since the effectiveness between time of update methods is similar, we evaluated the impact on churn between the Pull Packages. TABLE XVIII displays churn statistics (number of adds and deletes) between the different Pull Packages. Observing the first row we see that the Pull Package developed using patrols one through four has 2,729 NIINs. At the end of the next quarter (a quarterly update), we developed a Pull Package of 2,733 NIINs using patrols two through five. This results in 437 NIINs being added to the new Pull Package which weren't on the old Pull Package. Also there were 433 NIINs which were on the old Pull Package and no longer qualified for the new Pull Package. The second row shows churn results for the next quarterly update (351 adds and 495 deletes). When consecutive quarterly updates were done, 116 NIINs were added/deleted on the first Pull Package but deleted/added on the third update. When we skip a quarter (semi-annual updates) and then compute a Pull Package (third row), the number of adds and deletes increase as compared to each quarter's churn. However, the adds (672) and deletes (812) is less

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than the total 788 adds (437 + 351) and 928 deletes (433 + 495) generated by the two updates over the same time period. So it appears to be better to compute a Pull Package once a year. An annual computation minimizes needless churn does not negatively impact effectiveness, and keeps the process simple.

TABLE XVIII

Pull Package Churn

UPDATE FREQUENCY	DEVELOPED FROM PATROLS	OLD # NIINs	ADDS	DELETES	NEW # NIINs
QUARTERLY	1-4 ⇒ 2-5	2729	437	433	2733
QUARTERLY	2-5 ⇒ 3-6	2733	351	495	2589
SEMI-ANNUAL	1-4 ⇒ 3-6	2729	672	812	2589

NOTE: 116 NIINs Added/Deleted in Consecutive Quarterly Updates

B. IMPROVEMENT OF PERFORMANCE FOR HIGH MEC ITEMS.

1. APPROACH. Under our initial recommended Pull Package, MECs 110 and 116 had a NIIN effectiveness of 89% and 84%, respectively. During reference (3) of Appendix A, we were asked what can be done to further improve MEC 110 and 116 performance (to at least 90% NIIN effectiveness). In our initial Pull Package we included all MEC 110 and 116 items with at least one demand from any submarine during the four most recent patrols. In an effort to increase performance of MEC 110 and 116, we expanded the range of MEC 110 and 116 items. We accomplished this by adding to the Pull Package all MEC 110 and 116 items having at least one demand over a longer time interval (i.e., our entire demand history instead of four patrols). We then compared Process NIIN effectiveness for this expanded range (called entire history below) to the Process NIIN effectiveness under the FY89 Pull Package.

Currently there are eight TRIDENT submarines patrolling the Pacific. When our initial Pull Package was developed, we used data from only seven of the

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UICs, since one of the UICs didn't seem to have enough valid data to be included in the development of the Pull Package. After obtaining more recent demand history data, we then included the additional eighth UIC to develop a new Pull Package. Instead of using 28 patrols (seven UICs times four patrols), we now used 32 patrols (eight UICs times four patrols). Therefore, we also developed a Pull Package using 32 patrols vice 28 patrols. We computed Process NIIN effectiveness and compared it to both the FY89 and entire history alternative Process NIIN effectiveness to determine if including the eighth UIC increased effectiveness.

2. FINDINGS. TABLE XIX shows the Process NIIN effectiveness for the MEC 110 and 116 items under the FY89 approach (one demand in four patrols) and the alternative of using a longer time interval (entire demand history). The table displays the range, cost, Process NIIN effectiveness and Pull Package effectiveness by MEC across the seven UICs. An average is computed for NIIN and Pull Package effectiveness by MEC and UIC. Using a longer time horizon for MEC 110 and 116 items achieves an average of 89% Process NIIN effectiveness (a three percentage point increase). It also adds 456 NIINs to the Pull Package, increasing its total size from 2,553 NIINs to 3,009 NIINs. The cost of the total Pull Package increases by $127K (from $671K to $798K). Since NIIN effectiveness increased, it appears reasonable to use eight patrol's worth of demand for high MEC items.

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TABLE XIX

Process NIIN/Pull Package Effectiveness

(More patrols considered in Pull Package)

	ONE DEMAND IN FOUR PATROLS						ENTIRE DEMAND HISTORY					
MEC	110		116		BOTH		110		116		BOTH	
RANGE /COST	532/$215K		869/$2⁴5K		1401/$460K		683/$258K		1174/$329K		1857/$587K	
UIC	PROCESS NIIN	PULL PKG	PROCESS NIIN	PULL PKG	PROCESS NIIN	PULL PKG	PROCESS NIIN	PULL PKG	PROCESS NIIN	PULL PKG	PROCESS NIIN	PULL PKG
21036	93	7	87	8	90	7	96	5	88	6	91	6
21037	87	4	83	6	85	5	87	3	89	5	87	4
21038	90	6	78	9	84	8	91	4	82	7	85	6
21039	87	11	87	9	87	9	92	10	92	7	92	8
21040	88	17	89	10	88	9	91	6	91	8	91	7
21041	88	16	83	5	85	5	95	5	88	4	90	5
21042	90	6	83	11	86	9	92	5	86	9	88	8
AVG	89	7	84	8	86	7	92	5	88	7	89	6

However, when we added the eighth UIC (32 vice 28 patrols), Process NIIN effectiveness also increased for MEC 110 and 116 items. TABLE XX displays the results of using 32 patrols relative to the two alternatives described above. Considering 32 vice 28 patrols resulted in the MEC 110 Process NIIN effectiveness remaining the same (89%) and MEC 116 Process NIIN effectiveness increasing by six percentage points. Comparing the 32 patrols to the entire history shows that they both achieve an average for the 110 and 116 of 89%. Even though the both achieve the same average, the 32 patrol approach achieves this through higher Process NIIN effectiveness for the more critical group (116 MEC items). In addition, the 32 patrol approach has a better Pull Package

effectiveness (9% versus 6%), adds fewer items to the package (65 compared to 456) and results in a smaller additional cost ($45K versus $127K). Therefore, we conclude that it is better to add the eighth UIC to the data base, then using more history for the 110 and 116 MEC items.

TABLE XX

Alternative Method for Improving Performance for

MEC 110 and 116 Items

(More UICs considered in Pull Package)

	MEC	RANGE	COST	AVERAGE PROCESS NIIN EFFECTIVENESS	AVERAGE PULL PKG EFFECTIVENESS
FY89 (28 PATROLS)	110	532	$215K	89	7
	116	869	$245K	84	8
	BOTH	1401	$460K	86	7
ADDITIONAL UICs (32 PATROLS)	110	574	$214K	89	7
	116	892	$291K	90	10
	BOTH	1466	$505K	89	9
ENTIRE HIS-TORY FOR MEC 110 AND 116 ITEMS	110	683	$258K	92	5
	116	1174	$329K	88	7
	BOTH	1857	$587K	89	6

C. DEPTH COMPUTATION.

   1. APPROACH. In developing our Pull Package, we initially focused attention on the range and type of items the Pull Package should contain, not the depth of an item. Initially depth was computed using the simple average of units demanded over the 28 patrols (shown below).

$$\text{Depth} = \text{\# of units demanded over 28 patrols} \Big/ 28$$

An alternative approach to computing depth is to consider the average number of units demanded for the patrols that experienced demand (shown below).

$$\text{Depth} = \frac{\text{\# of units demanded over 28 patrols}}{\text{\# of patrols that experienced demand}}$$

This method more accurately predicts the average patrol demand requirements when a demand occurs (a conditional probability). We gathered the following statistics for the two different depth rules: The percent of NIINs with same depth quantities, the differences in quantities, the impact on partial fills, and unit effectiveness, where

$$\text{Unit effectiveness} = \left(\frac{\text{units satisfied from Pull Package} + \text{units satisfied from OBRA}}{\text{Total Units Demanded}}\right)$$

To evaluate the Pull Package in a real world environment, TRIDENT submarine personnel performed an actual SCOOP using the FY89 Pull Package. During a SCOOP, the UIC requisitions material from the Pull Package instead of the TRF. Statistics were gathered on how many requisitions were filled or partially filled. The test UICs involved were the USS GEORGIA and the USS ALABAMA. Pacific Fleet Polaris Material Office (PMOPAC) sent us a list of partially filled stock replenishment requisitions from this test for comparison under the alternative depth computation to see how many partial fills could have been avoided and how many more units would be satisfied.

2. **FINDINGS**. TABLE XXI compares the two different methods of computing depth by MEC. Recall our initial method involves computing the average patrol demand over all patrols but our alternative computes the average patrol demand <u>when a demand occurred</u>. The first column displays the percentage of items whose depth was equal using the two different depth rules. For example, 41% of the MEC 95 items had equal quantities. For MEC 110 and 116 items, it was 69% and 57%, respectively. The next column shows the

percentage of items where the quantity differed by one. The 85th percentile column shows that 85% of the time, the quantities differ by three or less units for MEC 95, and for MEC 98-107, by one or less for MEC 110, and by two or less for MEC 116. Results are also shown for the 95th percentile. For MEC 95 items, for example, the quantities differ by 11 or less 95% of the time.

TABLE XXI

Quantity Comparison between the Two Depth Rules

MEC	% QTY EQUAL	% DIFF BY 1	85TH PERCENTILE	95TH PERCENTILE
95	41	28	3	11
98-107	48	26	3	12
110	69	17	1	4
116	57	21	2	8

TABLE XXII displays the unit effectiveness and cost of our FY89 and alternative depth rules. Across all items, unit effectiveness increased eight percentage points and cost increased by $258K when using the alternative method. MEC 116 unit effectiveness increased by seven percentage points.

TABLE XXII

Unit Effectiveness/Cost Comparison

MEC	UNIT EFFECTIVENESS		COST	
	FY89	ALTERNATIVE	FY89	ALTERNATIVE
95	54	64	$126K	$192K
98-107	80	85	$ 85K	$107K
110	81	84	$215K	$286K
116	77	84	$245K	$344K
TOTAL	66	74	$671K	$929K

The next question is, how much better would the alternative method have done during the SCOOP test? Under the current method the USS GEORGIA had 64 partials during the test. It satisfied 656 units out of 1,178 units demanded, for a unit effectiveness of 56%. The alternative method reduced the number of partially filled requisitions from 64 to 25. It satisfied 988 units out of 1,178, for a unit effectiveness of 84%, an increase of 28 percentage points. For the USS ALABAMA the current method resulted in 38 partially filled requisitions and satisfied 122 out of 307 units demanded, for a unit effectiveness of 40%. The alternative method reduced the number of partially filled requisitions from 38 to 17 and satisfied 189 of 307 units demanded, for a unit effectiveness of 62%, an increase of 22 percentage points. Thus, we concluded that the alternative depth computation greatly reduces partially filled requisitions, greatly increases unit effectiveness, and should be used in future Pull Package computations.

D. OBRA COMPUTATION.

1. APPROACH. Under our initial procedure for determining items with sufficient OBRA, the following must be true.

COSAL Quantity $\geq$ 3

COSAL Quantity $> \dfrac{(\text{total demand} * 2)}{\# \text{ of patrols}}$

As with the Pull Package depth computations, the question arose as to whether we should be comparing the COSAL quantity to the average quantity per patrol or the average quantity for the patrols that experienced demands. Dividing by the number of patrols which experience demand may result in a more realistic estimate of sufficient OBRA items. We evaluated three methods for determining items with sufficient OBRA. In all cases the smallest COSAL quantity across all submarines must be greater than two for an item to be considered.

The three methods are:

- Based on the average patrol demand (used for FY89 Pull Package).

$$\text{If COSAL Quantity} > \frac{(\text{total demand} * 2)}{\# \text{ of patrols}}$$

- Based on the average patrol demand for patrols that experienced demand.

$$\text{If COSAL Quantity} > \frac{(\text{total demand} * 2)}{\# \text{ of patrols with demand}}$$

- Based on 85th percentile.

$$\text{If COSAL Quantity} > \text{MINIMUM} \begin{cases} \frac{(\text{total demand} * 2)}{\# \text{ of patrols}} + X \\[2ex] \frac{(\text{total demand} * 2)}{\neq \text{ of patrols with demand}} \end{cases}$$

where X = 3 for MEC = 95-107
           1 for MEC = 110
           2 for MEC = 116

The third method uses the average demand for patrols that experienced demand except for the NIINs where there are large differences between this approach and the average patrol demand (first method). The variable X restricts the third method to be no higher than the 85th percentile of differences between the first two methods. Using the 85th percentile method minimizes the effect of extreme demand observations (outliers).

A Pull Package was computed for each of these three methods to determine which method provides the best unit effectiveness. Unit effectiveness is units satisfied divided by units demanded. For Pull Package items demanded, the units satisfied was computed as follows:

Units Satisfied = Demand Quantity if Demand Quantity less than or
equal to Pull Package Quantity

otherwise,

Units Satisfied = Pull Package Quantity

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For all Non-Pull Package items with demand, we computed units satisfied as shown below.

Units Satisfied = Demand Quantity if Demand Quantity is less than or equal to half the COSAL Quantity

otherwise,

Units Satisfied = half the COSAL Quantity

2. <u>FINDINGS</u>. TABLE XXIII displays the unit effectiveness results of computing sufficient OBRA items based on the number of patrols undertaken (current method), the number of patrols with demand, and on the 85th percentile method. Based on the total average unit effectiveness, there is a maximum of two percentage points between the methods. But for critical MECs (110 and 116) the OBRA based on the total number of patrols provided the best average unit effectiveness of the three methods. Therefore, we concluded, since neither of the other two methods improved the unit effectiveness, the method of determining sufficient OBRA should remain based on the total number of patrols.

TABLE XXIII

Average Unit Effectiveness

	OBRA		
MEC	BASED ON # OF PATROLS	BASED ON # OF PATROLS W/DEMAND	BASED ON 85TH PERCENTILE METHOD
95	47	46	49
98-107	84	80	82
110	86	79	80
116	83	81	81
TOTAL	60	58	59

V. SUMMARY AND CONCLUSIONS

The SCOOP Logistics Planning team asked us to assist them in determining which spare repair parts to provide for the submarine, without knowing which parts are required, so the submarine may continue operations without returning to the TRF. The Pull Package must maximize the replenishment rate for NIINs demanded during the current patrol (especially critical NIINs), and keep the package size within practical limits.

The basic development of the Pull Package consisted of first determining the demand history based on four patrols from seven UICs, developing a Pull Package with items demanded on "y" number of patrols and "x" number of UICs, and then using the patrol period after the last history period to evaluate the Pull Package. We gathered statistics in terms of size and cost of the Pull Package, Process NIIN effectiveness and Pull Package effectiveness.

When the Pull Package was initially developed, we determined that a 90% Process NIIN effectiveness goal was not achievable based solely on demand. Due to first time demand, the best Process NIIN effectiveness was 83%. BRFs were introduced to supplement or replace a demand-based Pull Package. We showed that 90% Process NIIN effectiveness was not achievable with a Pull Package based solely on high BRF items. The best we could do was 75% Process NIIN effectiveness. Using high BRF items as a supplement to a demand-based Pull Package provided 90% NIIN effectiveness, but the size of the Pull Package (12,000 NIINs) was not practical. We determined that it's better to stick with only demand-based criteria rather than including high BRF, nondemand items.

During our evaluation, we determined that there were 1,459 NIINs with allowances which appear to be able to satisfy the demand from two normal

patrols. These NIINs, called OBRA, could be deleted as Pull Package can-
didates while increasing the effectiveness for similarly sized packages.
After reference (2) of Appendix A, we tailored the Pull Package to more
critical items. Here we mixed and matched the range cutoffs between MEC
groupings and the number of demands required, so that we could maximize
Process NIIN effectiveness. We could meet the 90% effectiveness goal for
critical NIINs when we tailored the Pull Package by MEC. TABLE XXIV displays
the FY89 Pull Package with projections to satisfy 84-89% of the most critical
NIINs and 73% of all NIINs. (Subsequent actual tests realized higher
effectiveness rates than we projected.)

TABLE XXIV

FY89 Pull Package

	# NIINs	COST	PROCESS NIIN EFFECTIVENESS	PULL PACKAGE EFFECTIVENESS
MEC 116 ITEMS WITH DEMAND ON AT LEAST ONE PATROL	869	$245K	84	8
MEC 110 ITEMS WITH DEMAND ON AT LEAST ONE PATROL	532	$215K	89	7
MEC 98-107 ITEMS WITH DEMAND ON AT LEAST TWO PATROLS	314	$ 85K	70	12
MEC 95 ITEMS WITH DEMAND ON AT LEAST THREE PATROLS FROM TWO DIFFERENT SSBNs	838	$126K	65	19
TOTAL	2553	$671K	73	12

We then determined how often to update this package. Two possibilities
were evaluated. They were quarterly (after each boat completes her next
patrol), and annually. We developed a Pull Package under each possibility and
compared Process NIIN effectiveness. The Process NIIN effectiveness changes

were no more than two percentage points. We also evaluated churn. With a quarterly update, more recent demand is used to build the Pull Package; however, churn increases. Thus changing the update frequency creates a trade-off between stability and responsiveness to new trends of the Pull Package. Our results suggest that the Pull Package be updated once a year. This is because an annual update causes no significant drop-offs in performance, decreases churn, and keeps the process simple, as compared to the quarterly update.

We also evaluated methods to increase Process NIIN effectiveness for MEC 110 and 116 items. We showed that using a longer time horizon for MEC 110 and 116 items increases the average Process NIIN effectiveness from 86% to 89%. But this method added 456 NIINs to the package and increased cost by $127K. At this point additional data became available, making it possible to add the eighth submarine (32 vice 28 patrols) to our evaluation. By doing this, Process NIIN effectiveness was also raised to about 89%, but fewer NIINS (65) were added to the Pull Package, and at a smaller increase in costs ($45K). Thus, it appears more reasonable to use all eight submarines with four patrols worth of demand data for all MECs rather than trying to use longer demand horizons for the higher MEC items.

In developing the Pull Package initially, we concentrated on which NIINs to include without an in-depth analysis of the depth calculations. Under our initial method, depth was computed using the simple average of units demanded over the 28 patrols. Our alternative method computed the average number of units demanded for the patrols that experienced demand. Comparing the two methods, we observed that 85% of the quantities differ by three or less units. The alternative method had an eight percentage points increase in overall unit

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effectiveness. It also increased MEC 116 unit effectiveness by seven percentage points. An actual SCOOP test was conducted using our Pull Package with depth computed using the current method. We evaluated a list of partially filled requisitions from two test submarines, to determine how the alternative method would fare. The alternative method reduced partially filled requisitions 55-61% and increased units satisfied 51-55%. Cost increased by 38%. With this increase of requisitions and units satisfied, it appears cost effective to use the alternative method to compute depth.

In terms of OBRA items, there were concerns about our method of computing sufficient OBRA items. The concern was that we may have overstated our sufficient OBRA items by using the simple average of units demanded over the 28 patrols. Alternative methods were to compute the average number of units demanded for the patrols that experienced demand, and take the minimum of the current method plus the 85th percentile difference. Each method was compared to an item's COSAL quantity when it was three or greater to determine sufficient OBRA items. A Pull Package was computed using each of these methods. The bottom line was that compared to the current method, neither of the other two methods made any improvement in unit effectiveness. We concluded that we should not change the method of determining sufficient OBRA items.

VI. RECOMMENDATIONS

We recommend computing SCOOP Pull Packages by:

- Using generic data (four patrols and eight UICs).
- Using demand-based items only.

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- Deleting items from consideration with sufficient on-board allowances to satisfy two patrols.

- Selecting range cuts by MEC.

- Basing depth on average demand quantity for the patrols that experienced demand.

- Computing Pull Packages once a year.

APPENDIX A: REFERENCES

1. Meeting between representatives of FMSO and the SCOOP Logistics Planning Team of 11 Jan 1989.

2. Meeting between representatives of FMSO and the SCOOP Logistics Planning Team of 28 Mar 1989.

3. Meeting between representatives of FMSO and the SCOOP Logistics Planning Team of 25 Apr 1989.

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13. ABSTRACT

Adverse conditions at the TRIDENT Refit Facilities (TRFs) may force submarines to obtain their replenishment at a non-Navy port. Replenishment requirements (Pull Package) are required, without knowledge of what was used in the current patrol, to provide the submarine with sufficient replenishment support to complete another patrol. The first part of this study evaluates alternative methods for computing Pull Packages. These methods include generic versus hull-tailored, demand-based versus the Best Replacement Factor (BRF) based, excluding items with sufficient On-Board Replacement Assets (OBRA), and using Military Essentiality Codes (MECs). The alternatives are evaluated in terms of effectiveness, size of package and cost. The second part of this study examines frequency of update and Pull Package refinements. We recommend deleting the OBRA items from consideration and annually computing a generic, demand-based Pull Package with range based on MEC and depth based on average demand quantity for those patrols experiencing demand.

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